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ADP015042

TITLE: Effect of Ultraviolet Light Irradiation on Thermionic Energy Converter

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TITLE: International Conference on Phenomena in Ionized Gases [26th] Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

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Effect of ultraviolet light irradiation on thermionic energy converter

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The laser light is irradiated to the converter and the output current characteristics are studied. The output current may be mainly produced by light of ultraviolet region when the sun light is irradiated to the converter.

1. Introduction

A thermionic energy converter is a generator that directly converts a heat into an electricity. In order to operate with lower emitter temperature, the method of light irradiation to the converter is proposed.[1] The output characteristics are examined in detail when the visible light is irradiated.[2] In wide wavelength range about 627nm, the output current is increased, and the peak current is about 40A/m^2 at the laser energy of 15mJ. But, this value is not enough for the practical application. The resonance light of infrared region is irradiated and the output current characteristics are measured. The very high output current is obtained by irradiating the resonance light at fairly lower laser energy comparing with that by the visible light.[3,4] When the wavelength is 852 nm, the emitter temperature of 945K, the vapor pressure 1.93Pa and the laser energy 1mJ, the output current is about 500A/m^2, the peak current is more than the 100 times of the visible light irradiation. However, the wavelength width of resonance light is very narrow. Then, the ultraviolet laser light is irradiated to the thermionic energy converter and the output characteristics are examined.

2. Experimental arrangement

The experimental arrangement is shown in Fig.1. The converter is made of cylindrical Pyrex glass with a diameter of 50mm and a length of 140mm. The converter has three windows for an incident light. The emitter has a tungsten spiral heater inside a cylinder made of nickel. The heater current can control the emitter temperature. On the other hand, the collector is a disk made of stainless steel and has a mesh made of molybdenum with a diameter of 20mm in center. The converter is set in an electric oven. The vapor pressure of cesium gas can be controlled by adjusting the oven temperature. A light source is a XeCl excimer laser. The excimer laser is a wavelength of 308 nm and a pulse half width of 30 ns. The diameter of laser beam is about 8mm and the maximum laser power is 15 mJ, because an aperture puts on the optical pass of the laser light. The laser light is irradiated to the space between the electrodes being parallel to both electrodes.

3. Output characteristics with ultraviolet light irradiation

3.1 Voltage-current characteristic

The voltage–current characteristic is shown in Fig. 2. "Short circuit current density" is defined by the output current density when the voltage between the electrodes is 0V. The waveform of the output current by the ultraviolet light irradiation has a very long half width comparing with that by the visible light irradiation, which is same as that by resonance light irradiation.

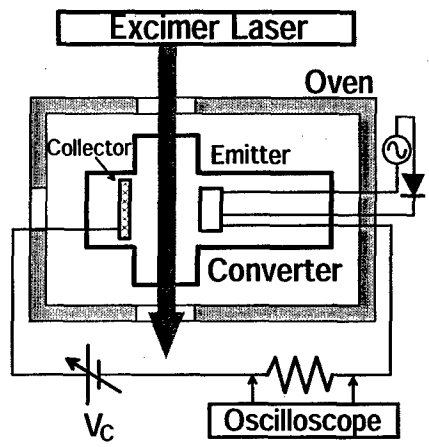

Fig. 1. Experimental arrangement

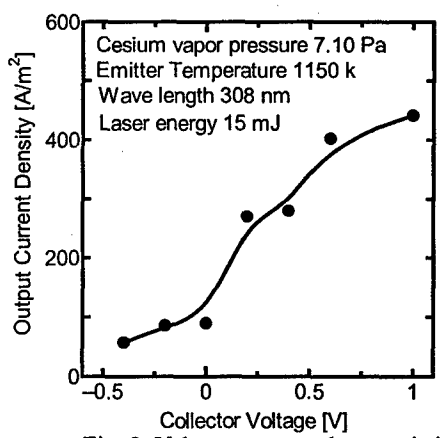

Fig. 2. Voltage-current characteristic

3.2 Cesium vapor pressure characteristic

The cesium in the converter adheres the electrodes and effectively reduces the work function. The work

function of emitter is decided by the cesium coating rate. The work function of cesium is 1.69 eV and one of tungsten is 4.62 eV. In high cesium vapor pressure, the work function of emitter reduces by absorbing the cesium on the surface of emitter. On the other hand, since the cesium of emitter surface evaporates in high emitter temperature, the work function increases.

The dependence of short circuit current density on cesium vapor pressure is shown in Fig. 3. The short circuit current density increases and reaches a peak because the work function of emitter decreases with increasing cesium vapor pressure. The movement of thermal electron and diffusion of cesium ion are prevented by cesium atoms. Therefore, the short circuit current density may increase by closing the space between the electrodes in high cesium density. When the emitter temperature is higher, the cesium vapor pressure at which the short circuit current density reaches a peak shifts to higher vapor pressure.

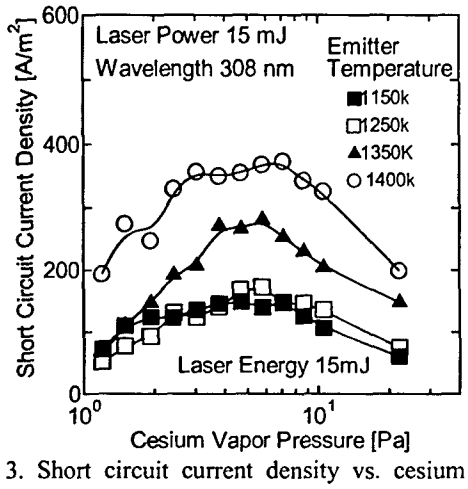

Fig. 3. Short circuit current density vs. cesium vapor pressure

3.3 Laser power characteristic

The short circuit current density vs. laser power is shown in Fig. 4. The short circuit current density increases with increasing laser power. In low cesium vapor pressure, the work function of emitter is the value which is high value of closely tungsten. The ion to neutralize the space charge is few, because the emitted thermal electron and the space charge are low. When the cesium vapor pressure is low, the short circuit current density shows a saturation.

3.4 Absorption characteristic

The absorption rate of ultraviolet light by cesium vapor is shown in Fig. 5. The absorption rate of ultraviolet light increases with increasing cesium vapor pressure. The absorption rate of ultraviolet light is lower than one of resonance light. However, it reaches to 70 % in this experimental condition, and is not negligible small.

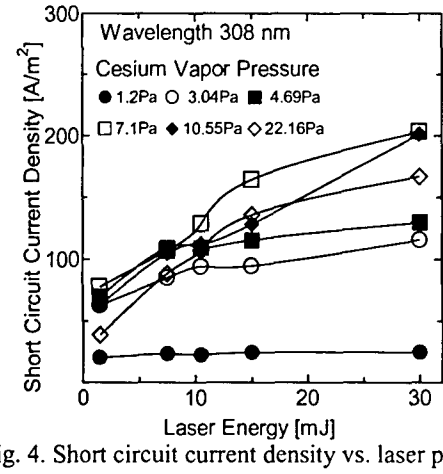

Fig. 4. Short circuit current density vs. laser power

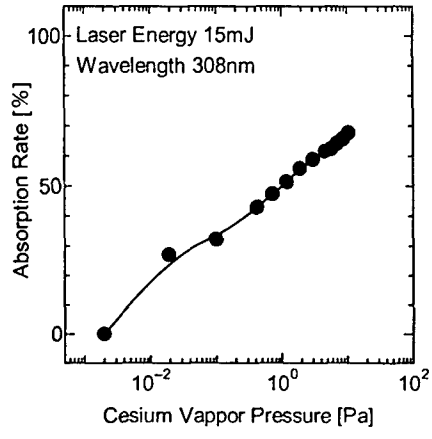

Fig. 5. Absorption rate

4. Conclusion

The ultraviolet laser light is irradiated to the thermionic energy converter and the output characteristics are measured. The short circuit current density obtained by ultraviolet irradiation is higher than that by visible light. The maximum short circuit current density reaches about 400 A/m^2. This is slightly low comparing with that by the resonance light. However, the absorption of ultraviolet light hardly depends on the wavelength, while the wavelength width of resonance absorption is very narrow. The output current may be fairly improved by ultraviolet light when sun light is irradiated to the converter.

5. References

[1] M. Knado, H. Furukawa, M. Ichikawa and S. Yokoi: Proc. 29th Intersociety. Energy Conversion Engineerign Conf., U.S.A., (1994).

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[4] T. Inaguma, N. Tsuda, and J. Yamada: XXV ICPIG, **1** (2001) 287.